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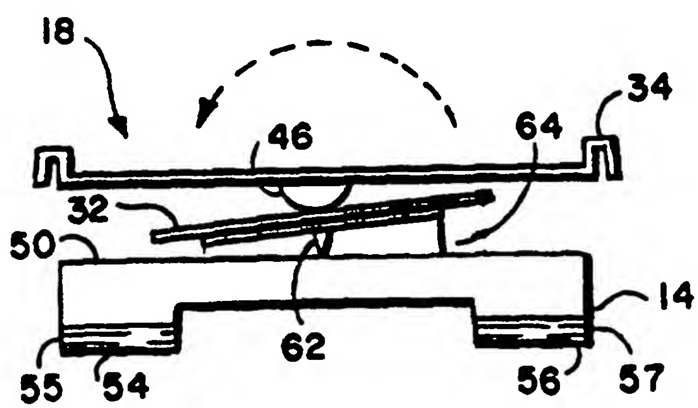
(54) Title: HEAD-GIMBAL ASSEMBLY WITH REDUCED STATIC ATTITUDE BIAS

(57) Abstract

A head-gimbal assembly for flying a slider in close proximity to the moving surface of a storage medium such as a magnetic disc (16), substantially without the effects of static attitude bias, includes a flexure (32) and a slider (14) that are joined by an adhesive (64). The assembly further includes a spacer (62), encompassed by the adhesive (64), connecting the slider (14) and the flexure (32). The spacer (62) has a shape effective for providing a pivot between the flexure (32) and the slider (14) in a position to allow adhesive joining of them without disturbing any static attitude bias of the flexure (32) so that the slider (14) is adhesively joined to the flexure (32) for flying substantially without the effects of static attitude bias from the flexure (32).



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HEAD-GIMBAL ASSEMBLY WITH REDUCED STATIC ATTITUDE BIAS

BACKGROUND OF THE INVENTION

The present invention relates to a transducer system for use in data storage systems, and more particularly to a head-gimbal assembly in disc type data storage systems.

BACKGROUND OF THE INVENTION

Many magnetic disc type data storage systems include read/write transducer systems with flying head-gimbal assemblies to provide a constant air bearing between the transducer head and the disc during read/write operations. The air bearing can be as thin as on the order of about one micro-inch, or even quasi-contact. The space between the transducer head must be large enough to prevent the transducer from crashing against the disc surface, yet small enough to prevent data error due to reduced signal strength.

The read/write transducer system for a magnetic disc system comprises a read/write or transducer element positioned along one side of a slider, which has an hydrodynamic planar surface. This surface is designed to fly the slider away from the disc surface on a thin film or laminar airflow caused by the disc's rapid rotation.

The slider is attached to a flexible gimbal, or flexure. The flexure is in turn mounted to a load beam. The load beam, generally speaking, is a cantilever spring member providing a bias force opposed to the force of the air bearing that lifts the slider away from the surface of the moving disc. The load beam is in turn mounted to a movably mounted disc drive actuator arm. A servo system of the disc drive moves the actuator arm to provide tracking for the transducer-head slider. A head-gimbal assembly generally includes the combination of a flexure and transducer-head slider.

Static attitude is a term that describes the parallelism of a slider's air bearing surface with respect to a disc surface without the influence from the spinning motion of the disc surface.

Ideally, the static attitude of a flexure should orient a slider such that its air bearing surface is parallel to the surface of the disc. This means there should be no static attitude bias in the roll direction and possibly only a small amount of static attitude bias in the pitch direction to promote flying of the slider. The predictability of a slider's flying characteristics is greatly enhanced when the static attitude of a slider has no roll bias. As indicated, a slight pitch bias in static attitude is helpful in establishing an air bearing during takeoff and flight. In operation, it is essential that the flexure have sufficient compliance to allow the slider freedom of roll and pitch to keep the desired air bearing gap or altitude as the slider glides on the air cushion above a spinning disc surface.

Typically a slider is connected to its flexure by an adhesive bond. During manufacture the slider is placed in a bonding fixture and an adhesive layer is applied between the slider and the flexure. The flexure is urged against the slider and held in place while the adhesive cures.

Flexures frequently have static attitude bias in the roll or pitch direction as the result of flexure manufacture. And this static attitude bias of a flexure effects a static attitude bias in the orientation of a slider carried by the flexure. During the adhesive joining of a slider to a flexure in a bonding fixture, any roll or pitch deflection in the slider is temporarily eliminated when the flexure is urged against the slider. But when the slider/flexure assembly is removed from the bonding fixture, the original roll or pitch deflection of the flexure reappears. And this static attitude bias of the flexure transfers to the slider adhesively joined to it. The static attitude bias of the slider carried by the flexure perniciously contributes to slider altitude variations during flight.

Disc manufacturers have continued to reduce the size of disk drives, while increasing drive capacity. For example, in recent years a typical high performance disc drive had a capacity of 200 to 300 megabytes stored on two discs of 3.5 inches in diameter. But in 1993 such a drive would store 300 to 500 megabytes on the same size and number of discs. As a result, the density of data on disc drives has increased--and is expected to continue to increase.

In the last year or so had risen to 200 million bits per square inch. And there has been an announcement of a drive with a density of over 500 million bits per square inch.

Increased data density on discs requires transducer recording/write head sliders fly closer to a disc surface. In this regard, flying heights presently are as low and 3 micro inches or less. As a result of these low flying heights, suspension assemblies must be more precise.

Moreover, demands have required a reduction in the size of sliders. Smaller sliders decrease access time and reduce cost. The use of smaller heads also increases the need for precisely constructed suspension assemblies, including more precisely constructed head-gimbal assemblies.

Also, as design tolerances for head-gimbal assemblies become stricter, production yields are reduced as a result of excessively large flexure static attitude bias in the pitch and roll or twist direction. This has driven up costs.

There is a need for a head-gimbal assembly that minimizes or eliminates static attitude bias.

SUMMARY OF THE INVENTION

An object of the invention is a head-gimbal assembly that flies without the undesired effects of static attitude bias.

Another object of the invention is increased production yields

of head-gimbal assemblies that fly without the undesired effects of static attitude bias.

In one aspect, these and other objects are attained by a head gimbal- assembly that includes a slider mounted on a flexure in an improved manner. The slider is a conventional type of slider with an air bearing surface on the disc facing side and a non-air-bearing surface on the opposite side. A spacer, which can be on the flexure, connects the flexure and the non-air-bearing surface of the slider and an adhesive layer encompasses the spacer and joins the slider in mounted relationship on the flexure. The shape and location of the spacer provides a pivot located between the non-air-bearing of the slider and the flexure in a position to allow the flexure and the slider to be assembled without disturbing any static attitude bias of the flexure. Accordingly, the slider flies during operation substantially without the effects of static attitude bias from the flexure.

In another aspect, these and other objects are also attained by a head-gimbal assembly that mounts a slider on a flexure using a spacer connecting the slider and the flexure where the shape and location of the spacer provides a pivot point positioned to allow the flexure and the slider to be adhesively joined without disturbing any static attitude bias of the flexure.

Moreover, in yet in another aspect, these and other objects are attained by a head-gimbal assembly assembled using a spacer as described herein where the shape and location of the

spacer provides a pivot line positioned to allow a flexure and slider to be adhesively joined without disturbing any static attitude bias of the flexure.

Then too, in still another aspect, these and other objects are attained by a head-gimbal-assembly that can include a load beam having a spacer with a shape and location that is effective during adhesively joining the slider and flexure together in a bonding fixture to provide a pivot between the load beam and the load pad of the bonding fixture when the load beam is brought into pressed contact against the load pad. The pivot allows the load beam to be pressed against the load pad without disturbing any static attitude bias of the load beam so that the slider is adhesively joined to the flexure in assembly for flying substantially without the effects of static attitude bias from the load beam.

Further, these and other objects are attained by the method of manufacturing a head-gimbal assembly that includes supplying a flexure and a slider with a pivot located between them. The flexure and the slider are brought into adhesive joining relationship with the pivot between them. The shape and location of the pivot allows the slider and the flexure to be adhered together without disturbing any static attitude bias of the flexure. When the slider and flexure are joined together with adhesive without disturbing any static attitude bias of the flexure, the slider is joined to the flexure for flying substantially without the effects of static attitude bias from the

flexure.

An advantage of the invention is a disc drive that is capable of effective reading and writing a high disc data densities.

Another advantage of the invention is improved control in slider flight, especially at low flying altitudes.

Yet another advantage of the invention is the improved ability to use smaller sliders.

Still another advantage is the ability to produce improved head-gimbal assemblies without the need to re-tool existing manufacturing equipment.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified showing in plan view of a magnetic disc drive with a head-gimbal assembly incorporating the principles of the invention.

Figure 2 is a simplified showing of the magnetic disc drive of Figure 1 in a side elevation view.

Figure 3 is an exploded perspective view of the under side of the head-gimbal assembly of the disc drive shown in Figures 1 and 2. The Figure shows a load beam, flexure, and magnetic transducer head slider.

Figure 4 is a perspective view of the under side of the

assembled head-gimbal assembly of Figure 3.

Figure 5 is an enlarged perspective view of the under side of the flexure of the head-gimbal assembly of Figures 3 and 4. The Figure more clearly shows a spacer formed on the under surface of the flexure. During manufacture, the spacer connects the flexure and the magnetic recording head slider according to the principles of the invention.

Figure 6 is a side elevation view of the flexure shown in Figure 5.

Figure 7 is a view in transverse section of the magnetic transducer head slider and flexure assembly of Figure 4.

Figure 8 is a plan view of an alternate embodiment of a flexure including two spaced apart spacers on the under side surface of the flexure according to the principles of the invention.

Figure 9 is a plan view of an other alternate embodiment of a flexure including an elongated type of spacer on the under side surface of the flexure according to the principles of the invention.

Figure 10 is a perspective view of a bonding fixture used to adhere a magnetic transducer head slider to a flexure in the manufacture of a head-gimbal assembly according to the principles of the invention. The flexure and load beam unit and the slider of Figures 1-7 are shown above the bonding fixture for placement on

the thereon.

Figure 11 is a simplified side elevation showing of a head-gimbal assembly in position on the fixture of Figure 10.

Figure 12 is a block diagram type showing of the process for manufacturing head-gimbal assembly according to the principles of the invention.

Figure 13 is a simplified showing in perspective of the fixture of Figures 10 and 11 with a modified load pad that includes a spacer positioned to operate on the load beam to reduce static attitude bias according to the principles of the invention.

Figure 14 is a perspective view of a head-gimbal assembly employing a spacer on the underside of its load beam according to the principles of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figures 1 and 2 are simplified showings of a magnetic disc drive 10 that includes a number of individual magnetic transducer or read/write head slider suspension assemblies 12 that each carries a magnetic transducer head slider 14 (see Figures 3 and 4). As shown, each of the suspension assemblies 12 is positioned above a rotatably mounted magnetic disc 16 and employs a head-gimbal assembly 18 according to the principles of the invention. Each of the slider suspension assemblies 12 also includes an actuator arm 20 pivotly mounted on a post 22. During operation of the disc

drive 10, a conventional disc drive tracking system (not shown) pivotly moves the suspension assemblies 12 in the direction indicated by the bi-directional arrow 24 in Figure 1 during positioning the magnetic transducer head slider 14.

Referring to Figures 3 and 4, it can be seen that the head gimbal assembly 18 includes a load beam 30, a flexure 32, and the magnetic transducer slider 14. The longitudinal axis or centerline of the head gimbal assembly 18 is indicated by the dashed line 33.

The load beam 30 is a somewhat tapered cantilever spring with side rails 34 and 36. A wider rear pad region 38 provides for joinder of the load beam 30 to an actuator arm 20 and includes opening 39 that is used for mounting on a bonding fixture during manufacture of the head-gimbal assembly 18. Further, the load beam 30 includes an electrical wire 40 that extends the length of the beam 30 along one side thereof. The wire 40 connects the magnetic transducer head slider 14 and the read/write channel electronics of the drive 10.

During operation, the load beam 30 provides a resilient biasing force on the head-gimbal assembly 18 toward the surface of its associated magnetic disc 16. To provide the resilient biasing force, the free position of the load beam 30 is tilted out of the plane of the actuator arm 20 toward the surface of its associated disc 16. During operation, The slider 14 flies on an air cushion established between it and the surfaces of the rotating disc. As a result, the normal operating position of the load beam 30 is

generally in the same plane as the actuator arm 20. Load beam free and operating positions are illustrated in U. S. Patent 5,115, 363, which is hereby incorporated by reference.

The flexure 32, which is a conventional thin springy member, includes an inner cantilever tongue 40. Also, the flexure 32, as shown, includes two alignment openings 42 and 43 for securing the flexure 32 to the load beam 30. It is noted that opening 43 is also used in mounting the flexure 32 and load beam 30 on a bonding fixture during assembly. Moreover, the bottom or under surface of the narrower free end 44 of the load beam 30 includes a dimple or small rounded protrusion 46 located on the longitudinal axis of the load beam 30. The dimple 46 provides a pre-loaded pivot surface against the mating top surface of the tongue 40. Accordingly, during operation, the dimple 46 allows the flexure 32 to provide flexibility both in the pitch and the roll directions for the slider 14, which is mounted thereon.

From Figures 3, 5-6, it can be seen that the tongue 40 extends rearward of the flexure 32 from its base end located at the forward end region of the flexure 32. The tongue 40 extends from its base end toward the rear of the flexure 32 to terminate at a free end thereof. A suitable adhesive, such as an epoxy adhesive, bonds the bottom surface 48 of the tongue 40 to the top surface 50 of the slider 14.

Other types of flexures can be used. For example, integrated flexures, which are well known in the art, can be also be used .

As is illustrated in Figure 7, the flexure 32 has unacceptable static attitude bias in the roll direction. A typical tolerance range in commercial practice today is from about +/- .5 degrees. It is noted, in practice, that flexures are manufactured both within and outside acceptable static attitude bias tolerances. The present invention can be used in both instances.

Still referring to Figures 3 and 4, the slider 14, as shown, is a conventional slider including on one side a generally planar non-air bearing top surface 50 and on the opposite side a configured bottom surface 52 that includes two spaced apart edge rails or skids 54 and 56. The rails 54 and 56 provide conventional air bearing surfaces. Also, the leading edge of each of the rails 54 and 56 includes a ramp 55 and 57 respectively, and the trailing edge of each of the rails 54 and 56 includes a read/write transducer or head 60.

In accordance with the invention, the head-gimbal assembly 18 includes a spacer shaped and located to provide a pivot between a flexure and slider in a position to allow the flexure and slider, which is held in a predetermined head-gimbal assembly orientation, to be brought into close spaced apart relationship for joining together during assembly without disturbing any static attitude bias of the flexure during joining. As a result, the slider 14 retains its predetermined head-gimbal orientation.

Referring more particularly to Figures 3, 5, 6, and 7, it can be seen that the tongue 40 includes a push-off or spacer 62

projecting from its bottom surface 48. And, as can be more clearly seen in Figure 7, the spacer 62 connects or bridges the flexure 32 and the slider 14. The spacer 62 is encompassed in a layer of adhesive 64 that joins the slider 14 to the flexure 32. Further, the spacer 62, as shown, resides on the longitudinal axis or centerline 33 of the tongue 40 (and the head gimbal assembly 18).

Referring to Figure 5, it can be seen that the tongue 40 includes a pair of spaced apart windows or openings 66_a and 66_b. This window allows ultraviolet light access to the uncured adhesive 64 during manufacture, as more fully explained herein after. In the figures, the adhesive 64 is an ultraviolet activated acrylic sold under the name "UV0001+VU", manufactured by Luxtrak Corporation. Other adhesives, such as anaerobic contact adhesives and epoxies can also be used.

As indicated, the flexure 32 has undesirable static attitude bias (indicated in the roll direction to the left as viewed in Figure 7 and as indicated by the arrow shown in dashed lines), which was present prior to assembly with the slider 14. As shown in Figure 7, the flexure 32 is adhesively joined to the slider 14 with its original static attitude bias unaffected. As a result, the position of the slider 14 in the assembled head-gimbal assembly 18, as indicated, is unaffected by the static attitude bias in the flexure 32.

As can be seen more clearly in Figure 7, the spacer 62 is conical in shape. As a result, the spacer 62 provides a pivot at

its apex that is a pivot point. This pivot allows the flexure 32 and the slider 14 to be brought into close spaced apart relationship during assembly for joining the two parts together adhesively with the pivot point at the apex of the spacer 62 in contact with the upper non-air-bearing surface of the slider 14. Consequently, the static attitude bias of the flexure 32 is unaffected during assembly because of the operation of the pivot provided by the spacer 62. And the orientation of the slider 14 is unaffected by any static attitude bias of the flexure 32.

The spacer 62 can be formed in a variety of ways. For example, it can be physically punched using conventional methods or can be produced using conventional etching methods. Regarding the latter method, a mask can be used with known acid etching methods to reduce the thickness of surrounding material of the flexure 32 to leave a protuberance like the spacer 62. In practice, spacers of from about .0005 to .001 inches in height have given good results, but other heights can be used. With regard to the height of a spacer like spacer 62, it is noted that the height must be enough to allow uninhibited roll movement at the lengthwise edges of a flexure. Otherwise, there is insufficient space allowing some undesired static attitude bias from the flexure to be transferred to the joined slider.

While the embodiment of the invention illustrated in Figures 1-7 place the spacer, such as spacer 62, on the underside of the flexure 32, a spacer according to the invention can be formed on

the non-air-bearing surface of a slider. This type of arrangement, as with the embodiment of Figures 1-7, provides a contact pivot between the non-air-bearing surface of a slider and a flexure in a position to allow the slider and flexure to be adhesively joined without disturbing any static attitude bias of the flexure so that the slider is joined to the flexure for flying without the effects of static attitude bias from the flexure. Any arrangement that provides a pivot between a slider and flexure as explained herein is within the scope of the invention. For example, a captive sphere positioned between a flexure tongue and slider that provides a pivot.

Moreover, spacers or push-offs according to the invention are not limited only to conical shapes to form a pivot point. For example, the invention can use arcuate or dimple type spacer shapes. Sharper apexes are generally preferred.

It is noted that the spacer 62 can also provide a conductive path for dissipating static charge build-up. This is especially important with MR heads, which are static sensitive. Conductive contact may be made without supplement, if the pivot is sharp enough, or a dab of conductive adhesive may be used to improve conductivity. Presently, it is common to use a dab of silver filled adhesive as a conductive bridge from a slider to a flexure as shown in Figures 5 and 6. In Figures 5 and 6 a conductive silver filled adhesive 68 can be seen in spaced relation with the spacer 62.

Figure 8 illustrates an alternative embodiment of a flexure according to the principles of the invention. Figure 8 shows a flexure 132, like the flexure 32, but includes two spaced apart identically shaped spacers 162 of the same conical shape and of the same height located on the underside surface of a flexure tongue 140 that lie on the tongue's longitudinal centerline. The tongue 140 and each of the spacers 162 are like the tongue 40 and the spacer 62. That is, as in the case of the spacer 62, each of the spacers 162 has a shape and location that provides a pivot between the flexure 132 and its associated slider. Because the spacers 162 are tapered like spacer 62, they provide spaced apart pivot points. But, unlike a single pivot point arrangement, the spaced apart pivots provided by the spacers 162 accommodate static attitude bias only in the roll direction; as a result, any static attitude bias in the pitch direction gets transferred to an adhesively joined slider. It may be advantageous, in certain circumstances to have the spacers be different heights.

Like the tongue 40, the tongue 140 includes a window 166 that allows ultraviolet light access to adhesive for the curing effect of the light on the adhesive. The tongue 140 also includes a spot of conductive adhesive 168 to ensure a conductive path for dissipating static charge.

Figure 9 illustrates another alternate embodiment of a flexure according to the principles of the invention. Figure 9 shows a flexure 172, like the flexures 32 and 132, but includes a single

elongated spacer 192 on the underside surface of a flexure tongue 180; as with the other spacers, the spacer 192 is on the longitudinal centerline of the tongue 180. And, as with the other spacers, the longitudinal spacer 192 has a shape and location that provides a pivot between the flexure 172 and its associated slider. As illustrated, the spacer 192 tapers from its base to provide a pivot in the form of a pivot line or knife edge. Accordingly, like the spaced apart pivots 162, the longitudinal spacer 192 accommodates static attitudes bias only in the roll direction; as a result, any static attitude bias in the pitch direction gets transferred to an adhesively joined slider. As shown, the spacer 192 is of uniform height along its length; however, it may be advantageous under certain circumstances to have an elongated spacer that has a height greater at one end than at the other end.

Like the tongues 40 and 140, the tongue 180 includes a window or opening 196 that allows access to adhesive by ultraviolet light for the curing effect of ultraviolet light on the adhesive. Further, the tongue 180 has a spot of silver filled adhesive 198 to ensure static charge dissipation.

Referring to Figures 10 and 11, there is shown a bonding fixture 210 used to adhere a slider to a flexure in the manufacture of a head-gimbal assembly. Figure 10 shows the joined together load beam 30 and the flexure 32 above the fixture 210 for mounting thereon. The slider 14 is also shown above the fixture 210 for placement thereon.

The fixture 210 includes a mounting suspension support 220, a load pad 224 with a load beam support 226, a tooling alignment post 228, and a slider nest 230.

The load beam 30 and flexure 32 unit is mounted on the bonding fixture 210 by aligning the opening 39 (in the load beam 30) with the suspension support 220 and the opening 43 (in the flexure 32) with the tooling alignment post 228. The slider is placed on the fixture 210 by locating it on the slider nest 230.

Figure 11 illustrates the disposition of the pieces of the head-gimbal assembly 18 when they are positioned on the bonding fixture 210. From Figure 11 it can be seen that the bottom of the load beam 30 rests on the top edge surface of the load beam support 226, which should be located generally midway between the suspension support 220 and the slider nest 230. As shown, the load beam support 226 is positioned a distance "1/2" or midway between the suspension support 220 and the slider nest 230.

As seen in Figure 10, a load "L" is applied to the load beam 30 in a conventional manner just forward of the load beam support 226 to bring the flexure 32 and the slider 14 into urged together relationship for bonding the slider 14 to the flexure 32. It is noted that adhesive is applied to the slider 14 prior to urging the flexure 30 and the slider 14 together.

The support surfaces of the bonding fixture each lie in a horizontal plane. That is, the support surfaces of the mounting suspension support 220, the load pad 224 (including the top edge of

the load beam support 226), and the slider nest 230 all lie in a horizontal plane for proper assembly of head-gimbal assemblies. Such an arrangement of the support surfaces allows proper disposition of the various parts of each head-gimbal assembly for proper orientation of its slider. The goal is to have slider orientation be such that each slider flies substantially without the effects of static attitude bias closely above its disc surface. During assembly, the pivot between the slider 14 and the flexure 30 provided by the spacer 62 allows the flexure 32 and the slider 14 to be brought into close spaced apart relationship for adhesive joining without disturbing the static attitude bias of the flexure 30. Because of the horizontal disposition of the support surface of the slider nest 230, the slider 14 is initially tacked or adhered to the flexure 30 with its air bearing surface oriented in a horizontal plane for flying parallel to the surface of a disc during disc drive operation. And this orientation does not change when the assembled head-gimbal assembly 18 is removed from the bonding fixture 210 since there is no force from the flexure 30 to distort the orientation of the mounted slider 14.

Because the adhesive 64 requires curing by ultra violet light and thermal curing, the head-gimbal assembly 18 must be further processed. Figure 12 illustrates this further processing and shows an ultra violet lamp box 240 of conventional design and a thermal oven 242. As illustrated, the bonding fixture 210, with the slider 14 of the head-gimbal assembly 18 initially adhesively tacked to

the flexure 32, passes through the ultra violet lamp box 240 in a conventional manner. After the bonding fixture 210 leaves the box 240, the head-gimbal assembly 18 is taken out of the fixture 210 and placed in an oven tray 246 (in practice with other assemblies 18), which is passed through the thermal oven 260 for final curing treatment of the adhesive 64.

While adhesive joining of the slider 14 to the tongue 40 has been shown using an adhesive requiring both ultra violet and thermal curing, other adhesives can be used that does not require such a curing process to adhesively join the two parts. For example, one might use an anaerobic contact adhesive.

Figure 13 is a simplified showing of the fixture 210 with a modified load pad 224_a that includes a rounded dimple type spacer 226_a that replaces the load beam 226. The load beam 30, flexure 32, and the slider 14 are indicated by dashed lines. The shape and location of the spacer 226_a functions as the spacer 62, but operates on the load beam 30. That is, the spacer 226_a has a shape that provides a contact pivot located between the load beam 30 and the horizontal support surface of the load pad 224_a. The position of the contact pivot allows the flexure 32 and the slider 14 to be bought into close space apart relationship for adhesive joining without disturbing any static attitude bias of the load beam 30. Consequently, the slider 14 is joined to the flexure 32 for flying substantially without the effects of static attitude bias from the load beam 30.

Figure 14 illustrates the head-gimbal assembly 18 modified to include a conically shaped spacer 62_a on the underside surface of the load beam 30. The spacer 62_a is located to engage the support surface of the load pad 224 modified to be without the load beam 226. And, as with the spacer 226_a, the spacer 62_a has a shape that provides a pivot between the load beam 30 and the horizontal support surface of the modified load pad 224. The position of the spacer 62_a allows the flexure 32 and the slider 14 to be brought the into close spaced apart relationship for adhesive joining without disturbing the static attitude bias of the load beam 30 so that the slider 14 is joined to the flexure for flying substantially without the effects of static attitude bias from the load beam 30.

Figure 15 shows a modified load pad 224_b for use with the bonding fixture 210. The load pad 224_b is modified to replace the load beam 226 with an elongated spacer 226_b that lies along the longitudinal axis of the fixture 210 (and of the load beam 30 mounted on the fixture 210. The spacer 226_b provides the same type of pivot that the other spacers disclosed herein so that a slider 14 can be adhesively joined to the flexure 32 without the effects of static attitude bias from the load beam 30.

While the invention has been disclosed in a magnetic context, the invention is also useful in the optical field with optical discs where the slider carries an objective lens.

It is apparent that within the scope of the invention modifications and different arrangements may be made other than disclosed herein. The disclosure is merely illustrative, the invention comprehending all variations thereof.

We claim:

1. A head-gimbal assembly for flying a slider in close proximity to the moving surface of a storage medium comprising:

a flexure;

a slider having an air bearing surface on one side thereof facing the moving surface during operation of the slider and having a non-air-bearing surface on the opposite side;

a pair of spaced apart spacers connecting the flexure and the non-air-bearing surface; and

an adhesive layer between the flexure and the non-air-bearing surface joining the slider in mounted relationship on the flexure, the spacer being shaped to provide a pivot that is located between the non-air-bearing surface and the flexure in a position to allow the flexure and the slider to be brought into close spaced apart relationship for adhesive joining in assembly without disturbing any static attitude bias of the flexure in the roll direction so that the slider is adhesively joined to the flexure in assembly for flying substantially without the effects of static attitude bias in the roll direction from the flexure.

2. The head-gimbal assembly of Claim 1 wherein the slider is a magnetic recording head slider.

3. The head-gimbal assembly of Claim 1 wherein the spacers are an integral part of the flexure.

4. The head-gimbal assembly of Claim 3 wherein the spacers are conical in shape.

5. The head-gimbal assembly of Claim 4 where the spacers are positioned on the longitudinal axis of the flexure.

6. The head-gimbal assembly of Claim 1 where the adhesive layer encompasses the spacers.

7. The head-gimbal assembly of Claim 1 where the spacers are the same height.

8. The head-gimbal assembly of Claim 3 wherein each of the spacers is shaped to provide a pivot point at its apex that engages the non-air bearing surface of the slider.

9. The head-gimbal assembly of Claim 8 wherein each of the spacers is conical in shape.

11. The head-gimbal assembly of Claim 10 wherein each of the spacers is the same height.

12. A head-gimbal assembly for flying a magnetic recording head slider in close proximity to the moving surface of a magnetic storage medium comprising:

a flexure;

a magnetic recording head slider having an air bearing surface on one side thereof facing the moving surface during operation and having a non-air-bearing surface on the opposite side;

an elongated spacer connecting the flexure and the non-air-bearing surface; and

an adhesive between the flexure and the non-air-bearing surface, the adhesive encompassing the spacer and joining the slider in mounted relationship on the flexure, each of the spacers being shaped and positioned to provide a pivot line located between the non-air-bearing surface and the flexure to allow the flexure and the slider to be brought into close spaced apart relationship for adhesive joining in assembly without disturbing any static attitude bias of the flexure in the roll direction so that the slider is adhesively joined to the flexure in assembly for flying substantially without the effects of static attitude bias in the roll direction from the flexure.

13. The head-gimbal assembly of Claim 3 wherein the spacer is an integral part of the flexure.

14. The head-gimbal assembly of Claim 13 where the spacer is on the centerline of the flexure.

15. A head-gimbal assembly for flying a magnetic recording head slider in close proximity to the moving surface of a magnetic storage medium comprising:

a flexure;

a magnetic recording head slider having an air bearing surface on one side thereof for facing the moving surface during operation of the slider and having a non-air-bearing surface on the opposite side thereof;

an elongated spacer fixed on a surface of the flexure to extend along the longitudinal axis thereof, the spacer extending away from the surface of the flexure with uniform height along its length to engage the non-air-bearing surface of the slider; an

an adhesive layer between the flexure and the non-air-bearing surface, the adhesive layer encompassing the spacer and joining the slider in mounted relationship on the flexure, the spacer providing a pivot line between the non-air-bearing surface and the flexure allowing the flexure and the slider to be brought into close spaced apart relationship for adhesive joining during assembly without disturbing any static attitude bias of the flexure in the roll direction so that the slider is adhesively joined to the flexure for flying substantially without the effects of static attitude bias in the roll direction from the flexure.

16. The head-gimbal assembly of Claim 15 wherein the elongated spacer has a uniform height along its length.

17. A head-gimbal assembly for flying a magnetic recording head slider in close proximity to the surface of a magnetic storage medium comprising:

an elongated flexure;

A magnetic recording head slider having an air bearing surface on one side thereof for facing the moving surface during operation of the slider and having a non-air-bearing surface on the opposite side thereof;

a pair of spaced apart spacers on a surface of the flexure, each of the spacers being located on the longitudinal axis of the flexure and extending away from the surface of the flexure to engage the non-air-bearing surface of the slider; and

an adhesive layer between the flexure and the non-air-bearing surface, the adhesive layer encompassing the spacers and joining the slider in mounted relationship on the flexure, each of the spacers being shaped to provide a pivot point engaging the non-air-bearing surface, the pivot points being positioned to allow the flexure and the slider to be brought into close space apart relationship for adhesive joining during assembly without disturbing any static attitude bias in the roll direction so that

the slider is adhesively joined to the flexure for flying substantially without the effects of static attitude bias in the roll direction from the flexure.

18. A head-gimbal assembly manufactured using a bonding fixture comprising a load pad at which pressure is applied during assembly, the head-gimbal assembly being for flying a magnetic recording head slider in close proximity to the moving surface of a magnetic storage medium comprising:

a flexure;

a magnetic recording head slider having an air bearing surface on one side thereof facing the moving surface during operation of the slider and having a non-air-bearing surface on the opposite side;

an adhesive layer between the flexure and the non-air-bearing surface joining the slider in mounted relationship on the flexure, the spacer being shaped to provide a pivot located between the non-air-bearing surface and the flexure in a position to allow the flexure and the slider to be brought into close spaced apart relationship for adhesive joining in assembly without disturbing any static attitude bias of the flexure so that the slider is adhesively joined to the flexure for flying substantially without the effects of static attitude bias from the flexure; and

a load beam, the flexure being mounted on one end thereof, a spacer on one side and between the ends thereof, the spacer being

shaped and positioned to provide a pivot between the load beam and the load pad of a bonding fixture when the load beam is brought into pressed contact against the load pad during adhesive joining of the slider and the flexure, the pivot allowing the load beam to be pressed against the load pad without disturbing any static attitude bias of the load beam so that the slider is adhesively joined to the flexure in assembly for flying substantially without the effects of static attitude bias from the load beam.

19. The method of manufacturing a head-gimbal assembly comprising:

supplying a flexure;

supplying a slider;

supplying a pair of spacers providing a pivot line between the slider and the flexure;

bringing the flexure and the slider into close adhesive joining relationship with the spacers therebetween, the spacers being positioned between them in a position to provide a pivot line allowing the slider and the flexure to be adhered together without disturbing any static attitude bias of the flexure; and

joining a slider and the flexure together with adhesive without disturbing any static attitude bias of the flexure so that the slider is joined to the flexure for flying substantially without the effects of static attitude bias from the flexure.

20. The method of Claim 19 wherein the spacers are provided by supplying a flexure having a pair of spaced apart spacers on the surface of one side thereof.

21. The method of Claim 19 wherein the step of joining the slider and the flexure together includes thermally treating the adhesive.

22. The method of Claim 19 wherein the step of joining the slider and the flexure together further includes exposing the adhesive to ultraviolet light.

23. The method of Claim 19 wherein the step of joining the slider and the together includes exposing the adhesive to ultraviolet light and thermally treating the adhesive after exposure of the adhesive to ultraviolet light.

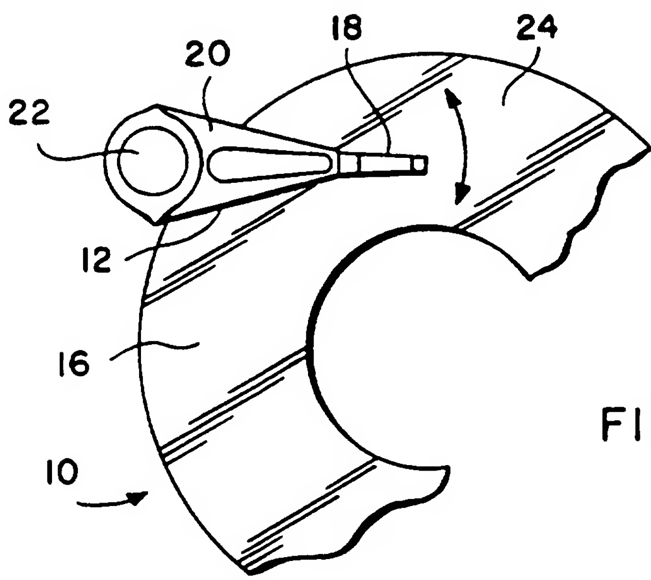

FIG. 1

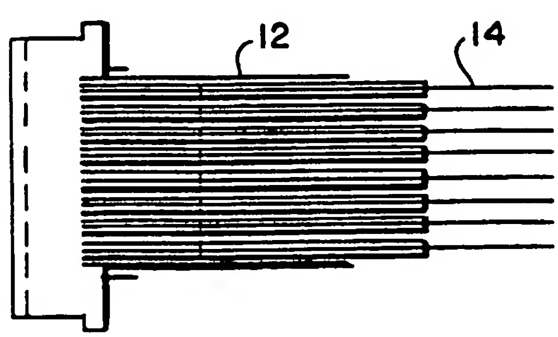

FIG. 2

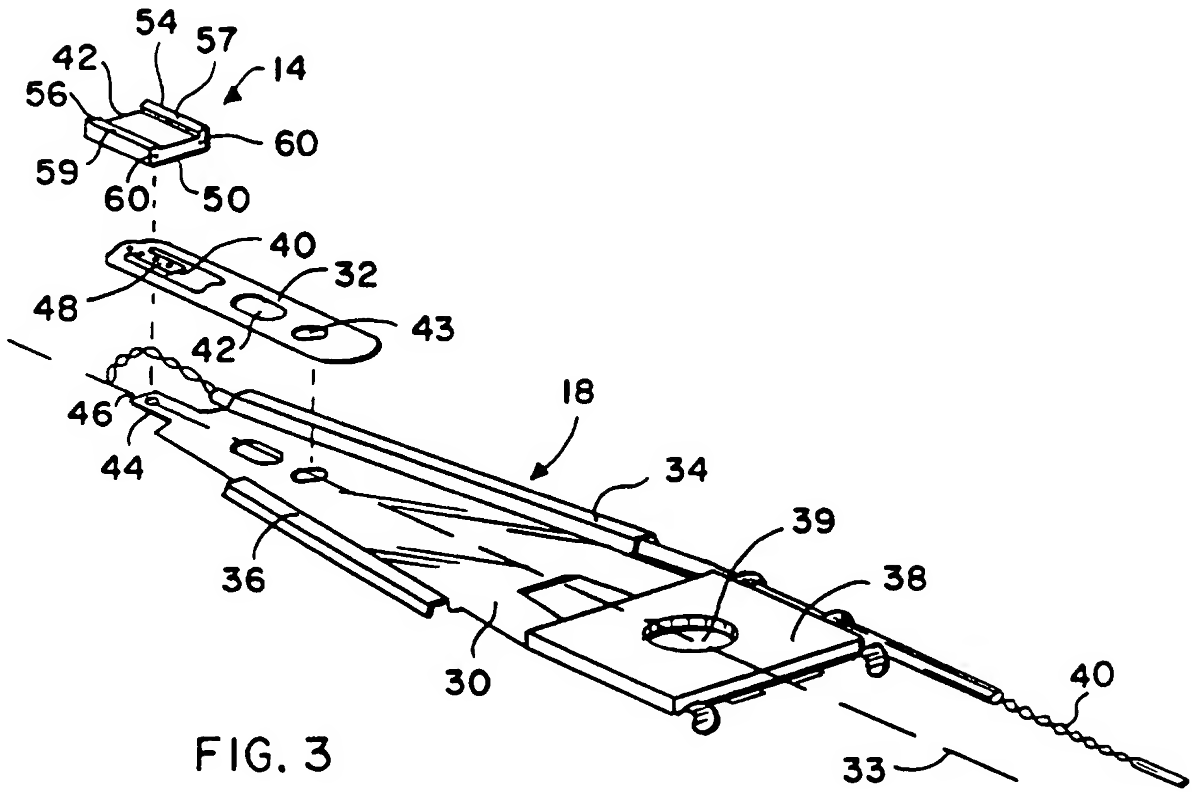
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FIG. 3

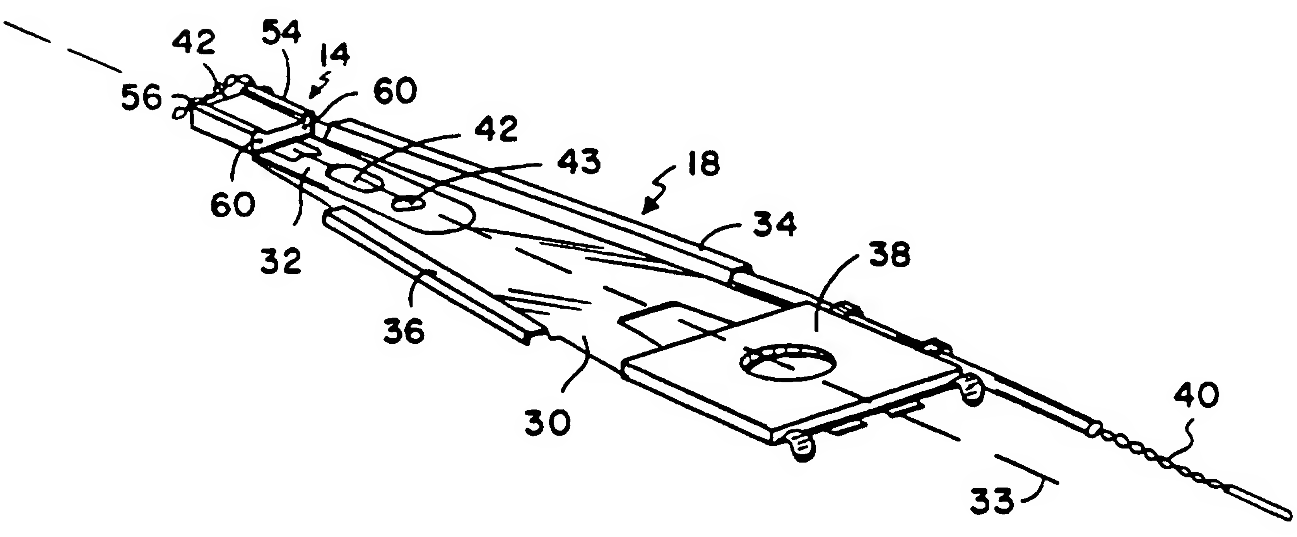
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FIG. 4

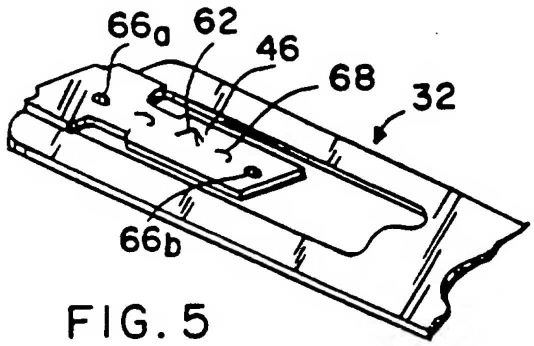


FIG. 5

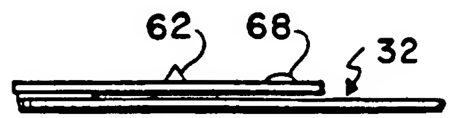


FIG. 6

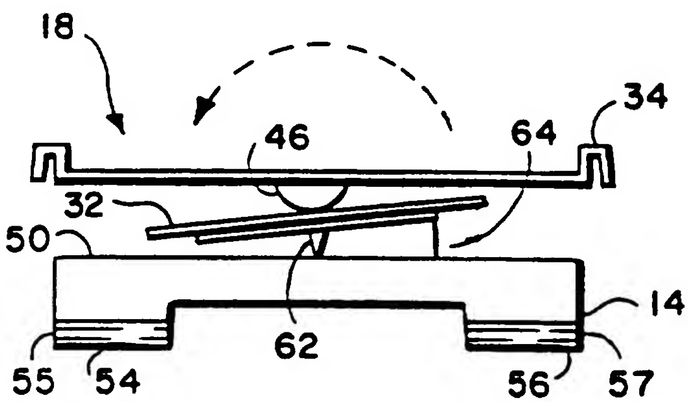


FIG. 7

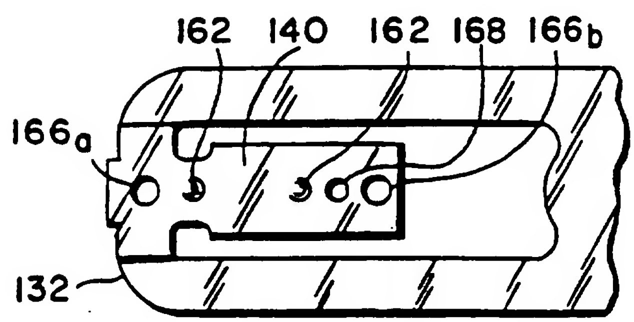
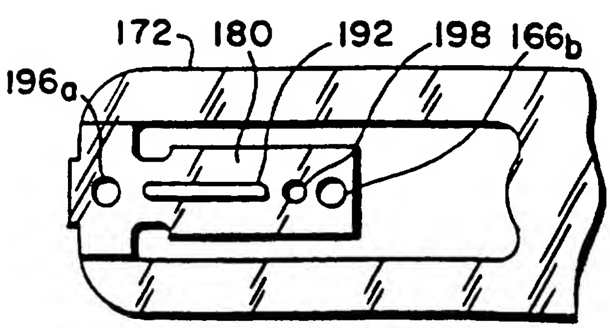


FIG. 8



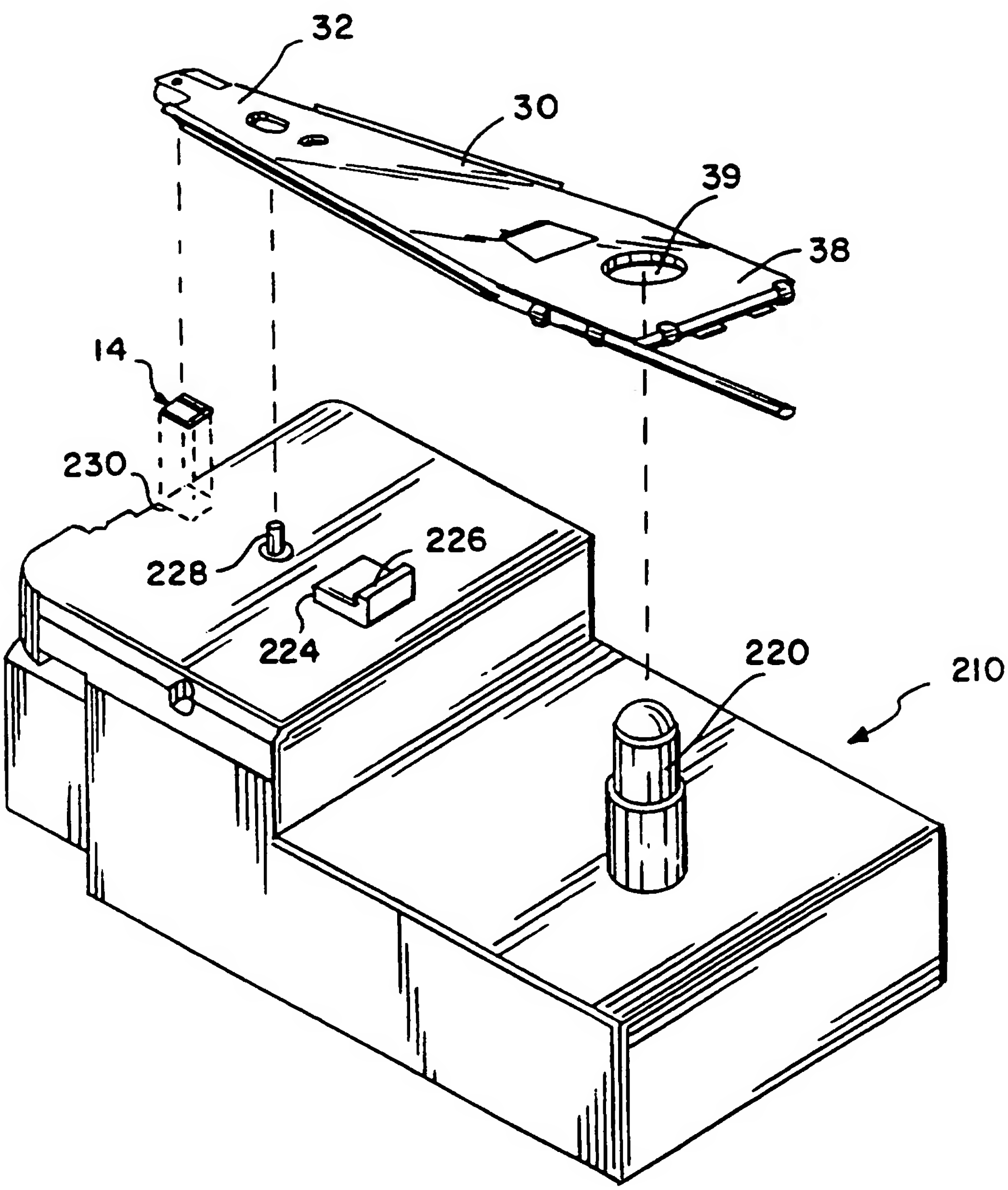


FIG. 10

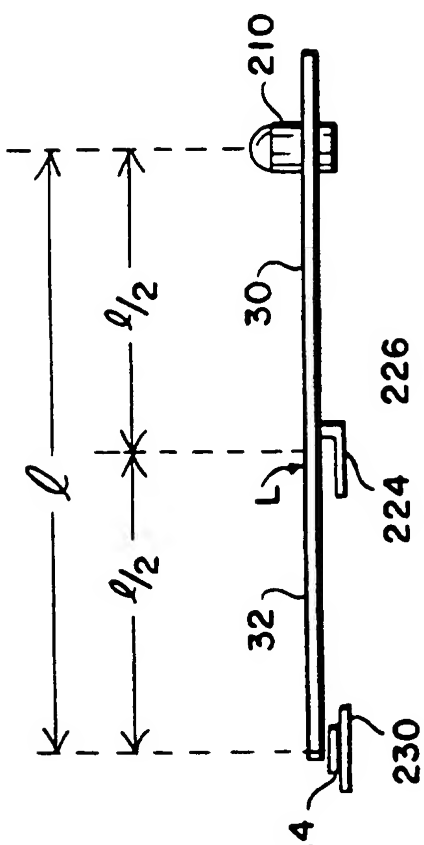


FIG. 11

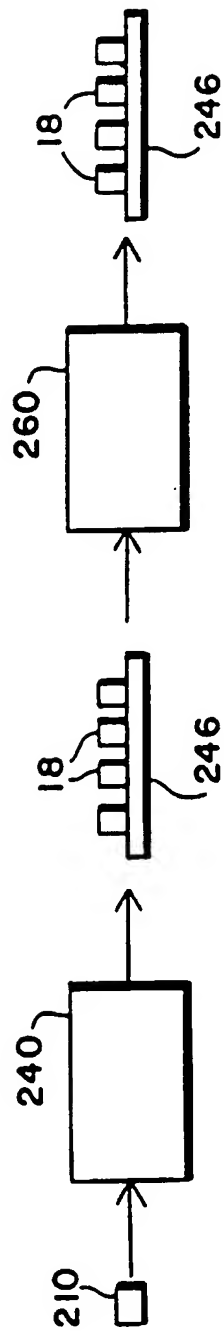


FIG. 12

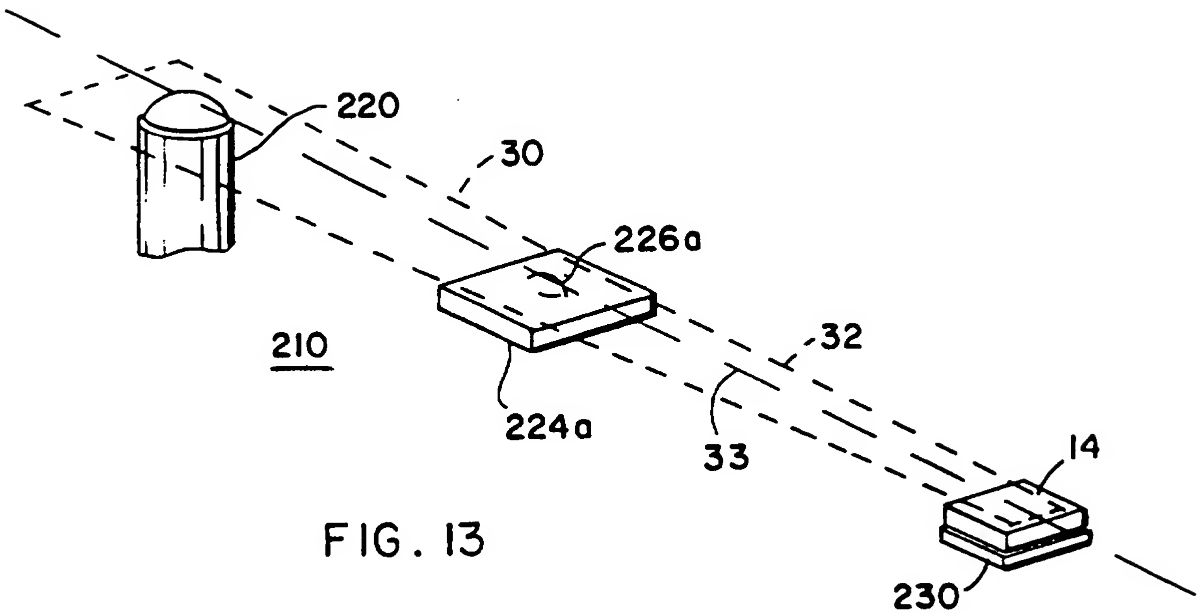


FIG. 13

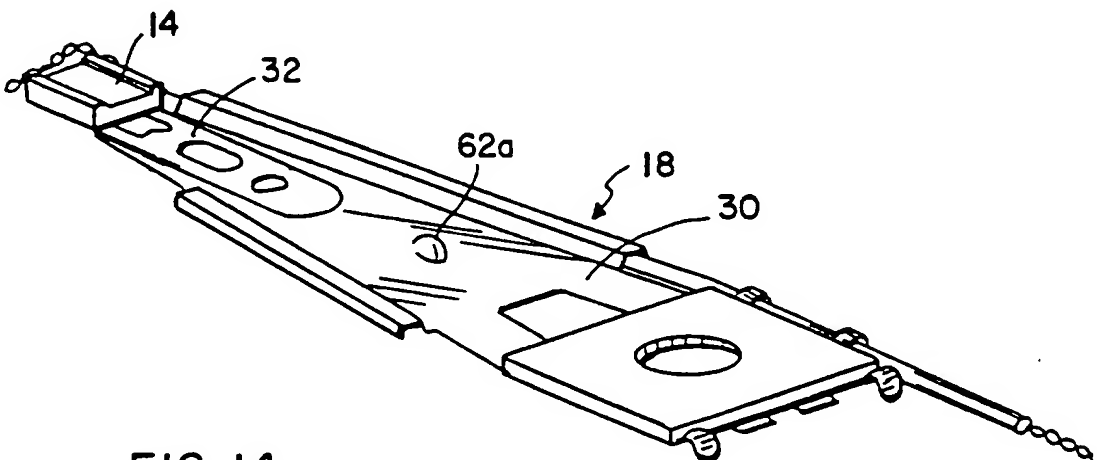


FIG. 14

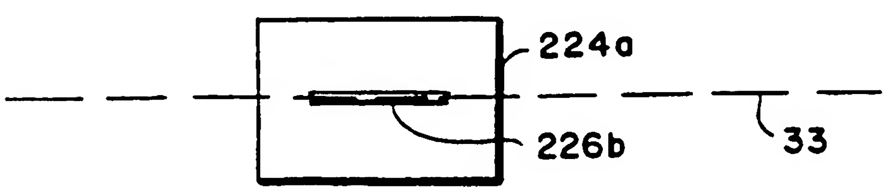


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/12488

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G11B 5/48, 5/54, 5/60, 21/16, 21/21
US CL :360/104, 103
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 360/104, 103, 97.01, 105, 106

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms: slider#, gimbal?, spacer#, protrusion#, dimple#, conical?, adhesiv?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	JP, 63-90084 (SEO) 20 April 1988, note figure 3(c).	1-9, 11-17, 19, 20 --------- 21-23
Y	US, A, 5,019,931 (OHWE ET AL) 28 May 1991, note figures 8, 10, and 11, and column 6 - line 57 to column 8 - line 15.	1-9, 11-17, 19-23
Y	US, A, 5,321,568 (HATAM-TABRIZI) 14 June 1994, note figure 4 and column 4 - lines 37 to 49.	1-9, 11-17, 19-23
Y	US, A, 5,299,081 (HATCH ET AL) 29 March 1994, column 5 - lines 15 to 18.	21-23

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 NOVEMBER 1995	05 DEC 1995
Name and mailing address of the ISA/US	Authorized officer

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/12488

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 10
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

claim 10 is missing. The numbering of the claims skips from claim 9 to claim 11. It is assumed for this search report that claim 11, which depends on missing claim 10, should depend from claim 9.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/12488

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5,282,103 (HATCH ET AL) 25 January 1994, note figure 14C and column 7 - lines 7 to 15.	